PATENT ABSTRACTS OF JAPAN

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(21)Application number : 07-247639

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(71)Applicant : FUJITSU LTD

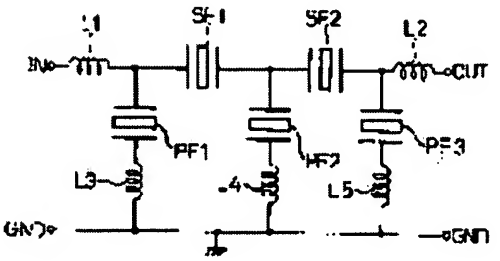
(72)Inventor : MINEMURA SEN
NAGATA KENJI
NAKAMURA YOSHITAKA

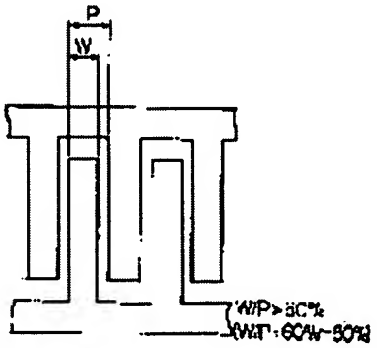
(54) SURFACE ACOUSTIC WAVE FILTER

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a surface acoustic wave (SAW) filter with which frequency characteristics are improved and the rate of frequency shift change caused by dispersion in electrode finger width is reduced by forming the ratio of elec trode finger width at a specified level corresponding to the electrode finger pitch of comb-line electrode at a SAW resonator.

SOLUTION: This SAW filter is formed by stepwisely connecting plural SAW resonators to serial SF1 and SF2 and parallel PF1-PF3. The respective SAW resonators are formed on a piezoelectric substrate as electrode patterns so that the respective electrode fingers of a pair of comb-line electrodes can be alternately inserted. Then, the electrode fingers of comb-line electrodes are formed in a certain pattern so that width W corresponding to its pitch P can be the ratio of 60% at least. Thus, the difference between a resonance frequency and an anti-resonance frequency can be relatively reduced.





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[Date of request for examination] 20.08.2001

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[Patent number]	3442202
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the respective electrode fingers of a pair of comb-line electrodes can be alternately inserted. Then, the electrode fingers of comb-line electrodes are formed in a certain pattern so that width W corresponding to its pitch P can be the ratio of 60% at least. Thus, the difference between a resonance frequency and an anti-resonance frequency can be relatively reduced.

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CLAIMS

[Claim(s)]

[Claim 1] In the surface acoustic filter which connects two or more surface-acoustic-waves resonators to a serial parallel in the shape of a ladder, and changes One pair of Kushigata electrodes for excitation with which an electrode pattern is formed and each of two or more of said surface-acoustic-waves resonators changes so that each electrode finger may put by turns and may be pinched on a piezo electric crystal substrate, The surface acoustic filter characterized by having the reflector which forms an electrode pattern in the both sides of the Kushigata electrode of this 1 pair, respectively, and grows into them, and carrying out pattern formation of the width of face (W) of the electrode finger to the pitch (P) of the electrode finger of said Kushigata electrode by at least 60% of ratio.

[Claim 2] The surface acoustic filter according to claim 1 characterized by carrying out pattern formation of the width of face (W) of the electrode finger to the pitch (P) of the electrode finger of said Kushigata electrode by 60% - 80% of ratio.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the resonator (SAW resonator) using the component using surface acoustic waves (SAW:Surface Acoustic Wave), and relate to the technique of improving the frequency characteristics of the filter (ladder form SAW filter) which connects with a serial parallel in the shape of a ladder, and grows into it combining this SAW resonator, especially. [two or more]

[0002]

[Description of the Prior Art] The example of 1 configuration of a typical SAW resonator is shown in drawing 9 . Among drawing, (a) is what showed the structure of a SAW resonator typically, and (b) shows it with a symbol notation. In drawing 9 (a), the SAW resonator by which 10 was formed in the piezo electric crystal substrate, and 20 was formed on the piezo electric crystal substrate 10 is shown. The piezo electric crystal substrate 10 is formed with piezo-electric ceramics, such as single crystals, such as lithium niobate (LiNbO3) and lithium tantalate (LiTaO3), or titanic-acid lead zirconate (PZT). moreover, the SAW resonator 20 equips with and constitutes one pair of Kushigata electrodes 21 and 22 for excitation (IDT:Inter-Digital Transducer), and the reflectors 23 and 24 arranged in these both sides of IDT -- having -- every -- IDT 21 and 22 and each reflectors 23 and 24 are formed by growing up aluminum (aluminum) by sputtering and carrying out patterning. Under the present circumstances, IDT22 by the side of IDT21 and the output (OUT) by the side of an input (IN) is each

electrode finger F1. And F2 Pattern formation is carried out so that it may put by turns and may be inserted. In addition, PIDT expresses spacing between each ****** electrode finger of IDT 21 and 22 (pitch), and is PREF. ****** inter-electrode spacing (pitch) of each reflectors 23 and 24 is expressed.

[0003] In a SAW resonator with such structure, by reflecting the surface acoustic waves (SAW) generated with the electrode for excitation (IDT 21 and 22) with the reflectors 23 and 24 arranged in the both sides, a standing wave is produced and it functions as exciting vibration which had high Q by it. In this case, the frequency excited is a pitch PIDT. And PREF It is determined depending on magnitude.

[0004] Two or more ladder form SAW filters as shown in drawing 1 (a) are constituted by connecting with a serial parallel in the shape of a ladder, combining such a SAW resonator suitably. The filter shape is determined by composition of the frequency characteristics by the resonance point which the SAW resonator connected to the serial has, and frequency characteristics with the resonance point and the antiresonance point which the SAW resonator connected to juxtaposition has in this ladder form SAW filter.

[0005] With the technique known conventionally, as shown in drawing 10 , pattern formation of the width of face (W0) of the electrode finger of the Kushigata electrode which constitutes the SAW resonator used for a ladder form SAW filter is carried out by 50% (=W0 / P) of ratio to the pitch (P) of an electrode finger, and it was being fixed to lambda/4. In addition, lambda is the resonance (or antiresonance) frequency f0. The wavelength of surface acoustic waves is shown and it is expressed by lambda=V/f 0 (however, V propagation velocity of surface acoustic waves).

[0006]

[Problem(s) to be Solved by the Invention] Generally, in order to raise the frequency passage property of an SAW filter, it is necessary to enlarge the signal magnitude of attenuation out of band. In other words, it is required that the characteristic curve should have started steeply in a passband and the boundary

section out of band, or the frequency passage property of an SAW filter should have fallen from the purpose of use (that is, use as a band-pass filter).

[0007] However, at the SAW filter known conventionally, there was nothing that can respond to satisfaction in this demand. Moreover, in case an SAW filter is manufactured, it originates in dispersion in the process, and the width of face of the electrode finger of the Kushigata electrode which constitutes the SAW resonator also varies (that is, it becomes uneven). Consequently, the propagation velocity (V) of the surface acoustic waves seen in macro changes, and resonance frequency (f0) shifts. This serves as evil, when carrying out stable production of the product, and it becomes the factor which reduces the yield.

[0008] This invention aims at offering the surface-acoustic-waves (SAW) filter which can make small the frequency shift rate of change to dispersion in the electrode digit resulting from a manufacture process, as a result can be contributed to improvement in the yield while it was created in view of the technical problem in the conventional technique mentioned above and improves frequency characteristics.

[0009]

[Means for Solving the Problem] In the SAW filter which according to this invention connects two or more SAW resonators to a serial parallel in the shape of a ladder, and changes in order to solve the technical problem of the conventional technique mentioned above One pair of Kushigata electrodes for excitation with which an electrode pattern is formed and each of two or more of said SAW resonators changes so that each electrode finger may put by turns and may be pinched on a piezo electric crystal substrate, It has the reflector which forms an electrode pattern in the both sides of the Kushigata electrode of this 1 pair, respectively, and grows into them, and the SAW filter characterized by carrying out pattern formation of the width of face of the electrode finger to the pitch of the electrode finger of said Kushigata electrode by at least 60% of ratio is offered.

[0010] if the ratio of the electrode digit to the pitch of the electrode finger of the

Kushigata electrode is further enlarged from 50 conventional% (the suitable operation gestalt of this invention -- at least 60%), the electromechanical coupling coefficient of the Kushigata electrode will become still smaller. Therefore, the difference (referred to as deltaf) of the resonance frequency and antiresonant frequency of an SAW filter becomes small. By this, the standup and falling of a characteristic curve can be made steep in a passband and the boundary section out of band. That is, the frequency passage property of an SAW filter can be raised.

[0011] Moreover, if the ratio of an electrode digit is changed, the propagation velocity of the surface acoustic waves seen in macro will change. This acts in the direction which makes resonance frequency and antiresonant frequency low (frequency shift). As an electromechanical coupling coefficient also changes and was mentioned above on the other hand, resonance frequency and antiresonant frequency are shifted. The frequency shift rate of change to the variation of an electrode digit becomes small, so that the ratio of an electrode digit will be enlarged, if both frequency shift amount of these is compounded.

[0012] Therefore, by enlarging the ratio of an electrode digit, the frequency drift by the fluctuation factor of an electrode digit can be stopped, and stable production of the product can be carried out. This contributes to improvement in the yield. Furthermore, if the ratio of an electrode digit is changed, while the propagation velocity of surface acoustic waves and the electrostatic capacity of the Kushigata electrode will change, a difference appears in the variation of resonance frequency and antiresonant frequency. Therefore, it becomes possible to adjust delicately factors, such as pass band width which influences the property of an SAW filter, impedance matching, and center frequency, by using these change well.

[0013]

[Embodiment of the Invention] The configuration of the SAW filter concerning 1 operation gestalt of this invention is shown in drawing 1 . Among drawing, (a) shows the circuitry of an SAW filter and (b) shows some patterns of the

Kushigata electrode which constitutes the SAW resonator used in the circuit of (a). As shown in drawing 1 (a), the SAW filter concerning this operation gestalt has the gestalt of the ladder form SAW filter of the four-step configuration which changes combining two SAW resonators SF1 and SF2 connected to the serial to I/O (IN/OUT) as a fundamental configuration, and three SAW resonator PF1 connected to juxtaposition to I/O (IN/OUT) - PF3 the shape of a ladder. Furthermore, inductors L1, L2, L3, L4, and L5 are connected to these SAW resonators SF1 and SF2, PF1, PF2 and PF3, and a serial, respectively.

[0014] in addition -- although illustration is not carried out -- every -- one pair of Kushigata electrodes for excitation which form an electrode pattern and change so that each electrode finger may put by turns and may be pinched on a piezo electric crystal substrate as the SAW resonator was shown in drawing 9 (a) -- this -- it has the reflector which forms an electrode pattern in the both sides of one pair of Kushigata electrodes, respectively, and grows into them. In drawing 1 (b), P expresses the pitch (spacing between one pair of ****** electrode fingers of the Kushigata electrode) of the electrode finger of the Kushigata electrode, and W expresses the width of face of an electrode finger.

[0015] In this operation gestalt, pattern formation of the width of face (W) of the electrode finger of the Kushigata electrode of a SAW resonator is carried out to the pitch (P) of an electrode finger by the larger ratio (W/P> 50%) than 50% (conventional form). About selection of the ratio (W/P) of this electrode digit, it can respond easily by changing suitably the exposure time at the time of electrode pattern formation, for example.

[0016] As for the ratio (W/P) of this electrode digit, in the suitable example of this invention, it is desirable to select to 60% - 80% so that it may mention later.

[0017]

[Example] this invention person investigated change of many properties at the time of changing the electrode digit of the Kushigata electrode about the SAW resonator used by the ladder form SAW filter of the four-step configuration concerning the operation gestalt shown in drawing 1 (a) and (b). As a sample

offering filter, the SAW filter whose center frequency is about 950MHz was used. In addition, in the configuration of drawing 1 (a), the inductance of each inductors L1-L5 was set as 1.5mH(s).

[0018] The frequency passage property of the SAW filter to change of an electrode digit is shown in drawing 2 , and the reflection property of the SAW filter to change of an electrode digit is shown in drawing 3 . The following data were acquired from these property graphs. Change of the difference (deltaf) of the resonance frequency to change of the ratio (W/P) of an electrode digit and antiresonant frequency is shown in drawing 4 .

[0019] The value of deltaf is small, so that drawing 4 may show and the ratio of an electrode digit increases. The variation of deltaf expresses extent with the standup of the curve in a passband and the boundary section out of band, and a steep change of falling in the frequency passage property shown at drawing 2 , and it becomes steep [change of a standup and falling] here, so that the value of deltaf is small here.

[0020] Change of a frequency shift of the resonance point and the antiresonance point over change of the ratio (W/P) of an electrode digit is shown in drawing 5 . Moreover, change of the pass band width to change of the ratio (W/P) of an electrode digit is shown in drawing 6 . The rate of change of a frequency shift is small, so that drawing 5 may show and the ratio (W/P) of an electrode digit increases. Moreover, it turns out that the rate of change of the resonance point is smaller than the rate of change of an antiresonance point. Therefore, pass band width also becomes small (refer to drawing 6).

[0021] When the ratio (W/P) of an electrode digit is 60% or less so that drawing 6 may show, pass band width becomes large too much, and since it is not desirable, considering as at least 60% is desirable [the ratio (W/P) of an electrode digit]. However, if an electrode digit (W) is enlarged recklessly, since it will also become making the power-proof nature of an SAW filter deteriorate, as a result shortening the life of an SAW filter, limiting to a suitable ratio is desirable.

[0022] Change of the life of the SAW filter to change of an electrode digit (W) is

shown in drawing 7 . In the example of illustration, the opposite numeral shows change of the life (T) over an electrode digit (W). In this test atmosphere (by the input of 1W, chip temperature is 85-degreeC), since there will be no use top problem of a product if there is a life for 8 hours or more, if the ratio (W/P) of an electrode digit is 80% or less, it will be satisfactory.

[0023] Moreover, change of the yield to change of the ratio (W/P) of an electrode digit is shown in drawing 8 . However, the relation of illustration was computed based on the frequency shift amount (refer to drawing 5) to the data of dispersion in an electrode digit (standard deviation), and the rate of change of an electrode digit. Since the ratio (W/P) of an electrode digit becomes [frequency shift rate of change] small to 75% (refer to drawing 5), the yield improves, but (refer to drawing 8) more than by it, since dispersion in an electrode digit becomes large, the yield tends to fall.

[0024] In addition, if the ratio (W/P) of the electrode digit W to a pitch P (it could be P= 2.5 micrometers in this example) is made 80% or more, since the width of face (P-W) of the insulating section is set to 0.5 micrometers or less, it is difficult [it] to form the electrode pattern of a SAW resonator on a piezo electric crystal substrate in the technical present condition. That is, manufacture of an SAW filter becomes difficult. Therefore, as for the ratio (W/P) of an electrode digit, considering as 80% or less is desirable.

[0025] As for the ratio (W/P) of the width of face to the pitch of the electrode finger of the above thing to the Kushigata electrode, it is desirable to consider as 60% - 80% of range. Since according to the configuration of the SAW filter concerning this example the former is larger than 50% (60% - 80%) and the ratio (W/P) of an electrode digit is carried out as explained above, the difference (deltaf) of resonance frequency and antiresonant frequency can be relatively made small, and the standup of the curve in a passband and the boundary section out of band and change of falling can be made steep by this so that drawing 4 may show. This contributes to an improvement of frequency characteristics.

[0026] Moreover, since the rate of change of a frequency shift can be controlled by enlarging the ratio (W/P) of an electrode digit so that drawing 5 may show, it becomes possible to carry out stable production of the product. This contributes to improvement in the yield. furthermore, factors which determine the property of an SAW filter by changing the ratio (W/P) of an electrode digit suitably in the desirable range (60% - 80%), such as pass band width and center frequency, -- texture -- it becomes possible to adjust densely.

[0027]

[Effect of the Invention] As explained above, the frequency shift rate of change to dispersion in the electrode digit which originates in a manufacture process while frequency characteristics are improvable by making into the conventional specific larger ratio than 50% the ratio of the electrode digit to the pitch of the electrode finger of the Kushigata electrode which constitutes the SAW resonator in an SAW filter according to this invention can be made small, and it becomes possible to aim at improvement in the yield.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the configuration of the SAW filter concerning 1 operation gestalt of this invention, and they are some pattern Figs. of the Kushigata electrode with which (a) constitutes the circuitry Fig. of an SAW filter and (b) constitutes the SAW resonator.

[Drawing 2] It is drawing showing the frequency passage property of the SAW filter to change of the ratio of an electrode digit.

[Drawing 3] It is drawing showing the reflection property of the SAW filter to change of the ratio of an electrode digit.

[Drawing 4] It is drawing showing change of the difference of the resonance frequency to change of the ratio of an electrode digit, and antiresonant frequency.

[Drawing 5] It is drawing showing change of a frequency shift of the resonance point and the antiresonance point over change of the ratio of an electrode digit.

[Drawing 6] It is drawing showing change of the pass band width to change of the ratio of an electrode digit.

[Drawing 7] It is drawing showing change of the life of the SAW filter to change of an electrode digit.

[Drawing 8] It is drawing showing change of the yield to change of the ratio of an electrode digit.

[Drawing 9] It is drawing showing the example of 1 configuration of a typical SAW resonator, and the perspective view in which (a) showed the configuration of a SAW resonator typically, and (b) are drawings having shown it with a symbol notation.

[Drawing 10] They are some pattern Figs. of the Kushigata electrode which constitutes the formal SAW resonator conventionally.

[Description of Notations]

PF1 - PF3 -- SAW resonator linked to juxtaposition

SF1, SF2 -- SAW resonator linked to a serial

L1-L5 -- Inductor

P -- Pitch of the electrode finger of the Kushigata electrode

W -- Width of face of an electrode finger

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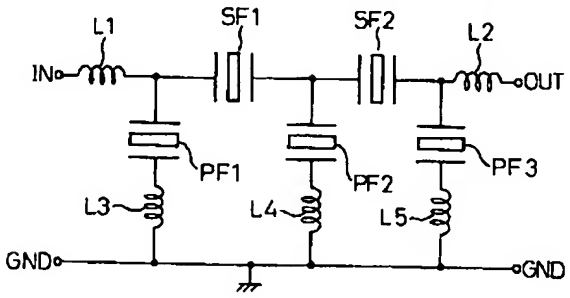
DRAWINGS

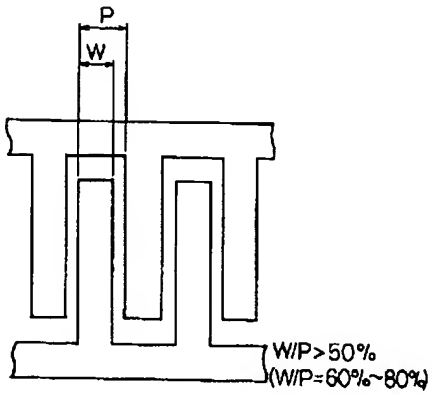
[Drawing 1]

本発明の一実施形態に係るＳＡＷフィルタの構成を示す図

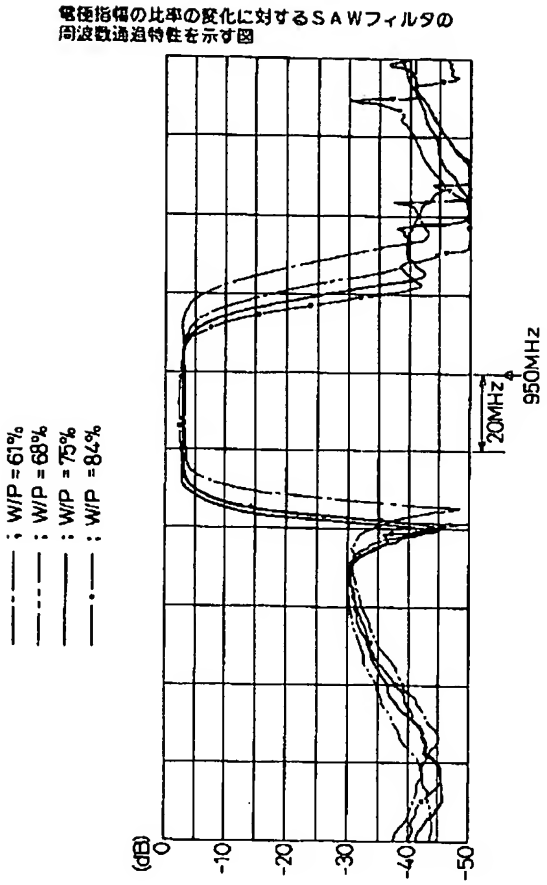
(a)



(b)

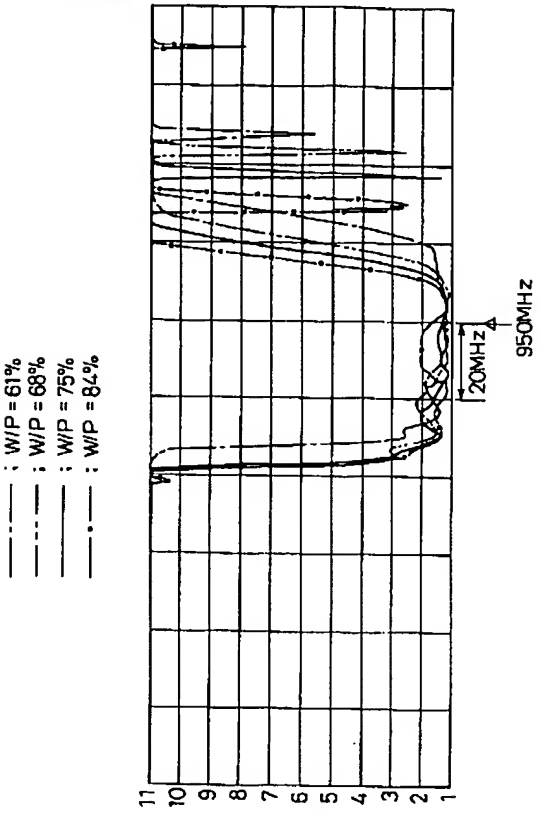


[Drawing 2]


電極指幅の比率の変化に対するＳＡＷフィルタの
周波数通過特性を示す図
W/P = 61%
W/P = 68%
W/P = 75%
W/P = 84%
950MHz
20MHz
(dB)
0
-10
-20
-30
-40
-50

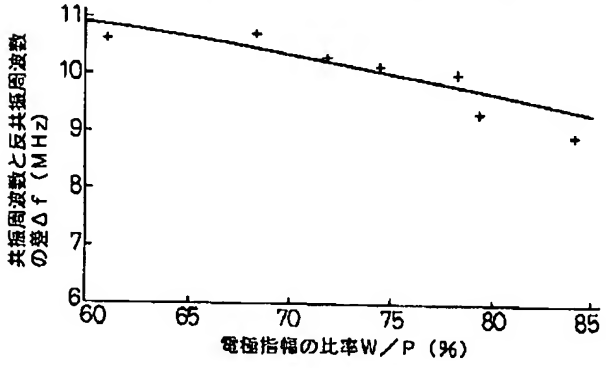
[Drawing 3]

電極指幅の比率の変化に対するＳＡＷフィルタの反射特性を示す図

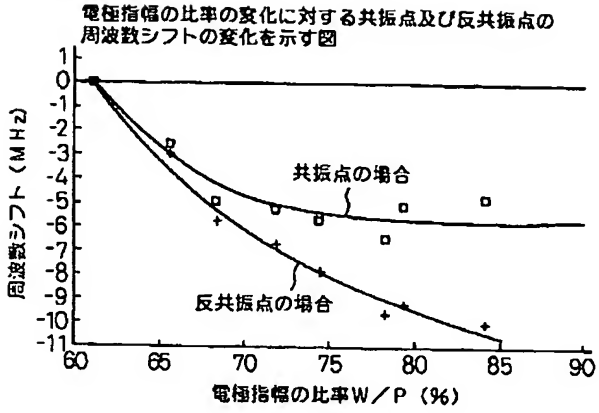


[Drawing 4]

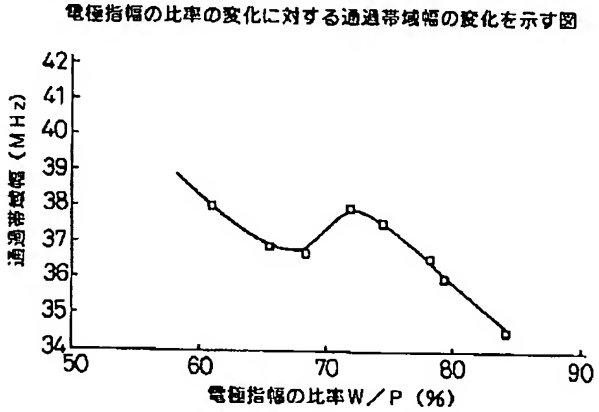
電極指幅の比率の変化に対する共振周波数と反共振周波数の差の変化を示す図



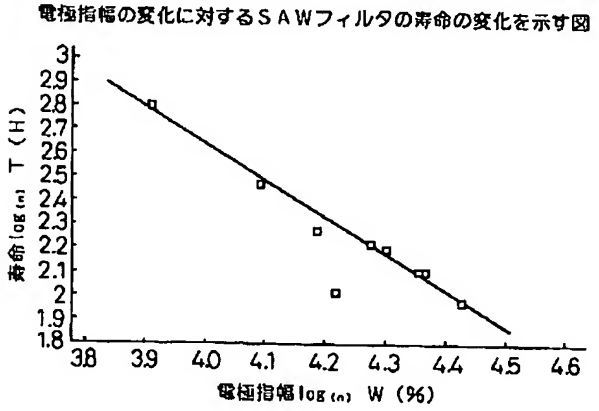
[Drawing 5]



[Drawing 6]

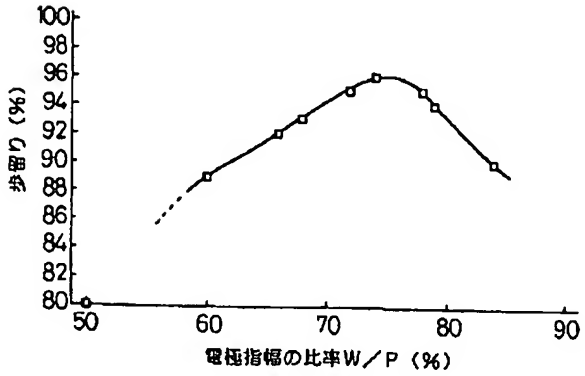


[Drawing 7]



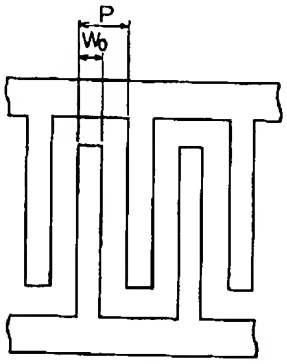
[Drawing 8]

電極指幅の比率の変化に対する歩留りの変化を示す図



[Drawing 10]

従来形のＳＡＷ共振器を構成している梯形電極の一部のパターン図



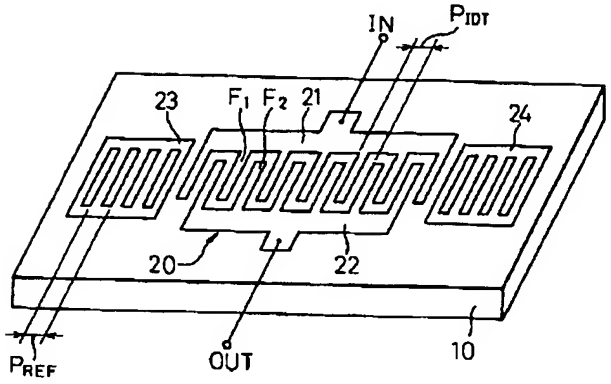
$W_0/P = 50\%$

$W_0 = \lambda/4$

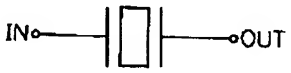
[Drawing 9]

典型的なＳＡＷ共振器の一構成例を示す図

(a)



(b)



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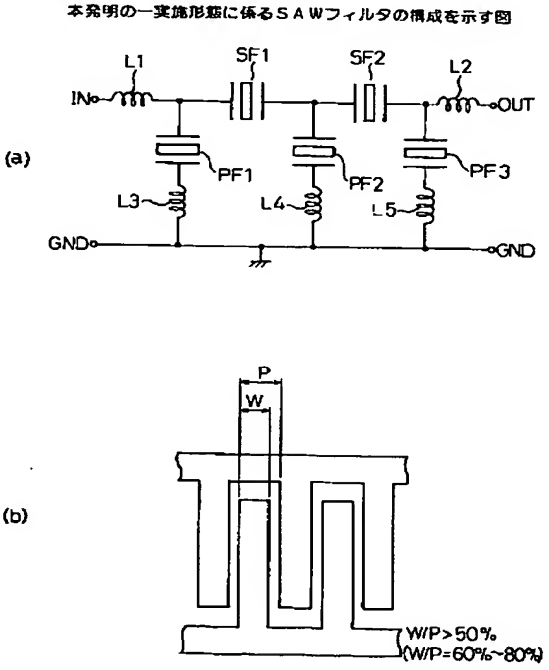
(54) 【発明の名称】表面弾性波フィルタ

(57) 【要約】

【課題】　本発明は、表面弾性波（ＳＡＷ）フィルタに関し、周波数特性を改善すると共に、製造プロセスに起因する電極指幅のばらつきに対する周波数シフト変化率を小さくし、ひいては歩留りの向上に寄与することを目的とする。

【解決手段】　複数のＳＡＷ共振器を直並列に梯子状に接続して成るＳＡＷフィルタにおいて、各ＳＡＷ共振器が、圧電体基板の上にそれぞれの電極指が交互に差し挟まれるように電極パターンを形成して成る励振用の１対の櫛形電極と、該１対の櫛形電極の両側にそれぞれ電極パターンを形成して成る反射器とを有し、上記櫛形電極の電極指のピッチＰに対する電極指の幅Ｗを少なくとも６０％の比率でパターン形成するように構成する。



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【特許請求の範囲】

【請求項１】　複数の表面弾性波共振器を直並列に梯子状に接続して成る表面弾性波フィルタにおいて、

前記複数の表面弾性波共振器の各々が、圧電体基板の上にそれぞれの電極指が交互に差し挟まれるように電極パターンを形成して成る励振用の１対の櫛形電極と、該１対の櫛形電極の両側にそれぞれ電極パターンを形成して成る反射器とを有し、

前記櫛形電極の電極指のピッチ（Ｐ）に対する電極指の幅（Ｗ）を少なくとも６０％の比率でパターン形成したことを特徴とする表面弾性波フィルタ。

【請求項２】　前記櫛形電極の電極指のピッチ（Ｐ）に対する電極指の幅（Ｗ）を６０％～８０％の比率でパターン形成したことを特徴とする請求項１に記載の表面弾性波フィルタ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、表面弾性波（ＳＡＷ：Surface Acoustic Wave ）を利用する素子を用いた共振器（ＳＡＷ共振器）に係り、特に、かかるＳＡＷ共振器を複数個、直並列に組み合わせて梯子状に接続して成るフィルタ（ラダー形ＳＡＷフィルタ）の周波数特性を改善する技術に関する。

【０００２】

【従来の技術】図９には典型的なＳＡＷ共振器の一構成例が示される。図中、（ａ）はＳＡＷ共振器の構造を模式的に示したもので、（ｂ）はそれをシンボル表記で示したものである。図９（ａ）において、１０は圧電体基板、２０は圧電体基板１０の上に形成されたＳＡＷ共振子を示す。圧電体基板１０は、例えばニオブ酸リチウム（$LiNbO_3$）やタンタル酸リチウム（$LiTaO_3$）等の単結晶、或いは、チタン酸ジルコン酸鉛（ＰＺＴ）等の圧電セラミックで形成されている。また、ＳＡＷ共振子２０は、１対の励振用櫛形電極（ＩＤＴ：Inter-Digital Transducer）２１及び２２と、該ＩＤＴの両側に配設した反射器２３及び２４とを備えて構成され、各ＩＤＴ２１，２２及び各反射器２３，２４は、例えばアルミニウム（Ａｌ）をスパッタリングにより成長させパターニングすることにより形成される。この際、入力（ＩＮ）側のＩＤＴ２１及び出力（ＯＵＴ）側のＩＤＴ２２は、各々の電極指F_1及びF_2が交互に差し挟まれるようにパターン形成される。なお、P_{IDT}は各ＩＤＴ２１，２２の隣合う電極指間の間隔（ピッチ）を表し、P_{REF}は各反射器２３，２４の隣合う電極間の間隔（ピッチ）を表している。

【０００３】このような構造を持つＳＡＷ共振器では、励振用電極（ＩＤＴ２１，２２）で発生した表面弾性波（ＳＡＷ）をその両側に配設した反射器２３，２４で反射させることにより定在波を生じさせ、それによって高いＱを持った振動を励起するように機能する。この場

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合、励振される周波数は、ピッチP_{IDT}及びP_{REF}の大きさに依存して決定される。

【０００４】このようなＳＡＷ共振器を複数個、直並列に適宜組み合わせて梯子状に接続することにより、例えば図１（ａ）に示すようなラダー形ＳＡＷフィルタが構成される。かかるラダー形ＳＡＷフィルタにおいてそのフィルタ特性は、直列に接続されたＳＡＷ共振器が持つ共振点による周波数特性と、並列に接続されたＳＡＷ共振器が持つ共振点及び反共振点による周波数特性の合成により決定される。

【０００５】従来知られている技術では、図１０に示すように、ラダー形ＳＡＷフィルタに用いられるＳＡＷ共振器を構成している櫛形電極の電極指の幅（W_o）は、電極指のピッチ（Ｐ）に対して５０％（$=W_o/P$）の比率でパターン形成されており、$\lambda/4$に固定されていた。なお、λは共振（又は反共振）周波数f_oでの表面弾性波の波長を示し、$\lambda=V/f_o$（但し、Ｖは表面弾性波の伝播速度）によって表される。

【０００６】

【発明が解決しようとする課題】一般に、ＳＡＷフィルタの周波数通過特性を向上させるためには、帯域外の信号減衰量を大きくする必要がある。言い換えると、ＳＡＷフィルタの周波数通過特性は、その使用目的（つまり帯域通過フィルタとして用いること）から、通過帯域と帯域外の境界部において特性曲線が急峻に立ち上がり、或いは立ち下がっていることが要求される。

【０００７】しかしながら、従来知られているＳＡＷフィルタでは、かかる要求に満足に応えることができるものは無かった。また、ＳＡＷフィルタを製造する際に、そのプロセスのばらつきに起因して、ＳＡＷ共振器を構成している櫛形電極の電極指の幅もばらつく（つまり不均一となる）。その結果、マクロ的に見た表面弾性波の伝播速度（Ｖ）が変化し、共振周波数（f_o）がシフトする。これは、製品を安定生産する上で弊害となり、歩留りを低下させる要因となる。

【０００８】本発明は、上述した従来技術における課題に鑑み創作されたもので、周波数特性を改善すると共に、製造プロセスに起因する電極指幅のばらつきに対する周波数シフト変化率を小さくし、ひいては歩留りの向上に寄与することができる表面弾性波（ＳＡＷ）フィルタを提供することを目的とする。

【０００９】

【課題を解決するための手段】上述した従来技術の課題を解決するため、本発明によれば、複数のＳＡＷ共振器を直並列に梯子状に接続して成るＳＡＷフィルタにおいて、前記複数のＳＡＷ共振器の各々が、圧電体基板の上にそれぞれの電極指が交互に差し挟まれるように電極パターンを形成して成る励振用の１対の櫛形電極と、該１対の櫛形電極の両側にそれぞれ電極パターンを形成して成る反射器とを有し、前記櫛形電極の電極指のピッチに

対する電極指の幅を少なくとも６０％の比率でパターン形成したことを特徴とするＳＡＷフィルタが提供される。

【００１０】櫛形電極の電極指のピッチに対する電極指幅の比率を、従来の５０％から更に大きく（本発明の好適な実施形態では少なくとも６０％に）すると、櫛形電極の電気機械結合係数はより一層小さくなる。従って、ＳＡＷフィルタの共振周波数と反共振周波数の差（Δｆとする）は小さくなる。これによって、通過帯域と帯域外の境界部において特性曲線の立ち上がり及び立ち下がりを急峻とすることができる。つまり、ＳＡＷフィルタの周波数通過特性を向上させることができる。

【００１１】また、電極指幅の比率を変化させると、マクロ的に見た表面弾性波の伝播速度は変化する。これは、共振周波数と反共振周波数を低くする方向に作用する（周波数シフト）。その一方で、電気機械結合係数も変化し、上述したように、共振周波数と反共振周波数をシフトさせる。これら両方の周波数シフト量を合成すると、電極指幅の比率を大きくするほど、電極指幅の変化量に対する周波数シフト変化率は小さくなる。

【００１２】従って、電極指幅の比率を大きくすることで、電極指幅の変動要因による周波数変動を抑えることができ、製品を安定生産することができる。これは歩留りの向上に寄与するものである。さらに、電極指幅の比率を変化させると、表面弾性波の伝播速度及び櫛形電極の静電容量が変化すると共に、共振周波数と反共振周波数の変化量に違いが現れる。従って、これらの変化をうまく利用することで、ＳＡＷフィルタの特性を左右する通過帯域幅、インピーダンス整合、中心周波数等のファクタを微妙に調整することが可能となる。

【００１３】

【発明の実施の形態】図１には本発明の一実施形態に係るＳＡＷフィルタの構成が示される。図中、（ａ）はＳＡＷフィルタの回路構成を示し、（ｂ）は（ａ）の回路で用いられるＳＡＷ共振器を構成している櫛形電極の一部のパターンを示す。図１（ａ）に示すように、本実施形態に係るＳＡＷフィルタは、基本的な構成として、入出力（ＩＮ／ＯＵＴ）に対して直列に接続した２個のＳＡＷ共振器ＳＦ１及びＳＦ２と、入出力（ＩＮ／ＯＵＴ）に対して並列に接続した３個のＳＡＷ共振器ＰＦ１～ＰＦ３とを梯子状に組み合わせて成る４段構成のラダー形ＳＡＷフィルタの形態を有している。更に、これらのＳＡＷ共振器ＳＦ１，ＳＦ２，ＰＦ１，ＰＦ２及びＰＦ３と直列に、それぞれインダクタＬ１，Ｌ２，Ｌ３，Ｌ４及びＬ５が接続されている。

【００１４】なお、図示はしないが、各ＳＡＷ共振器は、図９（ａ）に示したように、圧電体基板の上にそれぞれの電極指が交互に差し挟まれるように電極パターンを形成して成る励振用の１対の櫛形電極と、該１対の櫛形電極の両側にそれぞれ電極パターンを形成して成る反射器とを有している。図１（ｂ）において、Ｐは櫛形電極の電極指のピッチ（１対の櫛形電極の隣合う電極指間の間隔）、Ｗは電極指の幅を表している。

【００１５】本実施形態において、ＳＡＷ共振器の櫛形電極の電極指の幅（Ｗ）は、電極指のピッチ（Ｐ）に対して５０％（従来形）よりも大きい比率（Ｗ／Ｐ＞５０％）でパターン形成されている。この電極指幅の比率（Ｗ／Ｐ）の選定については、例えば電極パターン形成時の露光時間を適宜変更することにより、容易に対応が可能である。

【００１６】後述するように、本発明の好適な実施例では、この電極指幅の比率（Ｗ／Ｐ）は６０％～８０％に選定するのが好ましい。

【００１７】

【実施例】本発明者は、図１（ａ）及び（ｂ）に示した実施形態に係る４段構成のラダー形ＳＡＷフィルタで用いられるＳＡＷ共振器に関して、櫛形電極の電極指幅を変化させた場合の諸特性の変化を調べた。供試フィルタとしては、中心周波数が約９５０ＭＨｚのＳＡＷフィルタを用いた。なお、図１（ａ）の構成において、各インダクタＬ１～Ｌ５のインダクタンスは１．５ｍＨに設定した。

【００１８】図２には電極指幅の変化に対するＳＡＷフィルタの周波数通過特性が示され、図３には電極指幅の変化に対するＳＡＷフィルタの反射特性が示される。これらの特性グラフから以下のデータを取得した。図４には電極指幅の比率（Ｗ／Ｐ）の変化に対する共振周波数と反共振周波数の差（Δｆ）の変化が示される。

【００１９】図４からわかるように、電極指幅の比率が増加するほどΔｆの値は小さくなっている。ここにΔｆの変化量は、図２に示した周波数通過特性において通過帯域と帯域外の境界部における曲線の立ち上がり及び立ち下がりの変化が急峻であるかどうかの程度を表しており、Δｆの値が小さいほど立ち上がり及び立ち下がりの変化は急峻となる。

【００２０】図５には電極指幅の比率（Ｗ／Ｐ）の変化に対する共振点及び反共振点の周波数シフトの変化が示される。また、図６には電極指幅の比率（Ｗ／Ｐ）の変化に対する通過帯域幅の変化が示される。図５からわかるように、電極指幅の比率（Ｗ／Ｐ）が増加するほど周波数シフトの変化率は小さくなっている。また、共振点の変化率は反共振点の変化率よりも小さいことがわかる。従って、通過帯域幅も小さくなる（図６参照）。

【００２１】図６からわかるように、電極指幅の比率（Ｗ／Ｐ）が６０％以下の場合には、通過帯域幅が大きくなりすぎて好ましくないため、電極指幅の比率（Ｗ／Ｐ）は少なくとも６０％とするのが好ましい。しかしながら、電極指幅（Ｗ）をむやみに大きくすると、ＳＡＷフィルタの耐電力性を劣化させることになり、ひいてはＳＡＷフィルタの寿命を短くすることにもなるため、適

当な比率にとどめるのが望ましい。

【００２２】図７には電極指幅（Ｗ）の変化に対するＳＡＷフィルタの寿命の変化が示される。図示の例では、電極指幅（Ｗ）に対する寿命（Ｔ）の変化を対数表示で示している。今回の試験環境（１Ｗの入力で、チップ温度が８５°Ｃ）においては、８時間以上寿命が有れば製品の使用上問題はないので、電極指幅の比率（Ｗ／Ｐ）が８０％以下であれば問題はない。

【００２３】また、図８には電極指幅の比率（Ｗ／Ｐ）の変化に対する歩留りの変化が示される。ただし、図示の関係は、電極指幅のばらつき（標準偏差）のデータと電極指幅の変化率に対する周波数シフト量（図５参照）を基に算出した。電極指幅の比率（Ｗ／Ｐ）が７５％までは周波数シフト変化率が小さくなるため（図５参照）、歩留りが向上するが（図８参照）、それ以上では電極指幅のばらつきが大きくなるため、歩留りは低下する傾向にある。

【００２４】なお、ピッチＰ（本実施例では、Ｐ＝２．５μｍとした）に対する電極指幅Ｗの比率（Ｗ／Ｐ）を８０％以上にすると、絶縁部の幅（Ｐ－Ｗ）は０．５μｍ以下となるため、技術の現状では、圧電体基板の上にＳＡＷ共振器の電極パターンを形成するのは困難である。つまり、ＳＡＷフィルタの製造が困難となる。従って、電極指幅の比率（Ｗ／Ｐ）は８０％以下とするのが好ましい。

【００２５】以上のことから、梯形電極の電極指のピッチに対する幅の比率（Ｗ／Ｐ）は、６０％～８０％の範囲とするのが好ましい。以上説明したように、本実施例に係るＳＡＷフィルタの構成によれば、電極指幅の比率（Ｗ／Ｐ）を従来の５０％よりも大きく（６０％～８０％）しているので、図４からわかるように、共振周波数と反共振周波数の差（Δｆ）を相対的に小さくすることができ、これによって、通過帯域と帯域外の境界部における曲線の立ち上がり及び立ち下がりの変化を急峻とすることができる。これは、周波数特性の改善に寄与するものである。

【００２６】また、図５からわかるように、電極指幅の比率（Ｗ／Ｐ）を大きくすることで周波数シフトの変化率を抑制することができるので、製品を安定生産することが可能となる。これは、歩留りの向上に寄与するものである。さらに、電極指幅の比率（Ｗ／Ｐ）を好ましい範囲（６０％～８０％）で適宜変化させることにより、ＳＡＷフィルタの特性を決定する通過帯域幅、中心周波数等のファクタをきめ細やかに調整することが可能となる。

【００２７】

【発明の効果】以上説明したように本発明によれば、ＳＡＷフィルタにおいてＳＡＷ共振器を構成している梯形電極の電極指のピッチに対する電極指幅の比率を、従来の５０％よりも大きい特定の比率にすることで、周波数特性を改善することができると共に、製造プロセスに起因する電極指幅のばらつきに対する周波数シフト変化率を小さくすることができ、歩留りの向上を図ることが可能となる。

【図面の簡単な説明】

【図１】本発明の一実施形態に係るＳＡＷフィルタの構成を示す図で、（ａ）はＳＡＷフィルタの回路構成図、（ｂ）はＳＡＷ共振器を構成している梯形電極の一部のパターン図である。

【図２】電極指幅の比率の変化に対するＳＡＷフィルタの周波数通過特性を示す図である。

【図３】電極指幅の比率の変化に対するＳＡＷフィルタの反射特性を示す図である。

【図４】電極指幅の比率の変化に対する共振周波数と反共振周波数の差の変化を示す図である。

【図５】電極指幅の比率の変化に対する共振点及び反共振点の周波数シフトの変化を示す図である。

【図６】電極指幅の比率の変化に対する通過帯域幅の変化を示す図である。

【図７】電極指幅の変化に対するＳＡＷフィルタの寿命の変化を示す図である。

【図８】電極指幅の比率の変化に対する歩留りの変化を示す図である。

【図９】典型的なＳＡＷ共振器の一構成例を示す図で、（ａ）はＳＡＷ共振器の構成を模式的に示した斜視図、（ｂ）はそれをシンボル表記で示した図である。

【図１０】従来形のＳＡＷ共振器を構成している梯形電極の一部のパターン図である。

【符号の説明】

ＰＦ１～ＰＦ３…並列に接続したＳＡＷ共振器

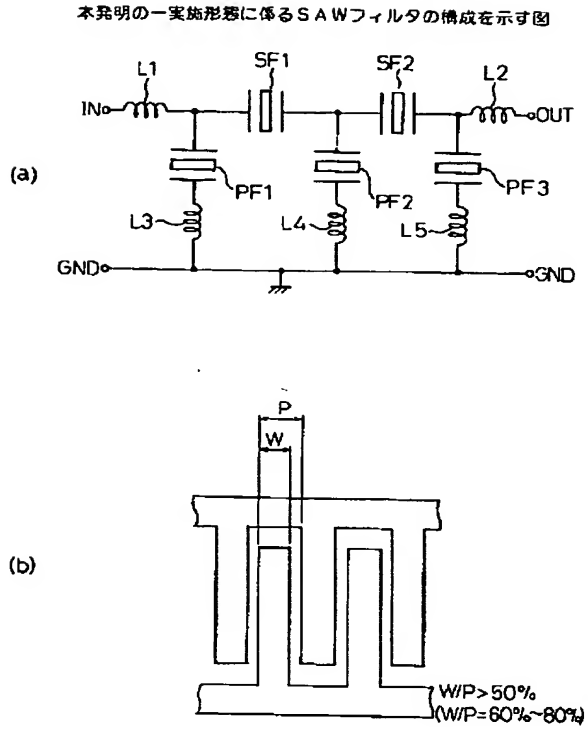
ＳＦ１，ＳＦ２…直列に接続したＳＡＷ共振器

Ｌ１～Ｌ５…インダクタ

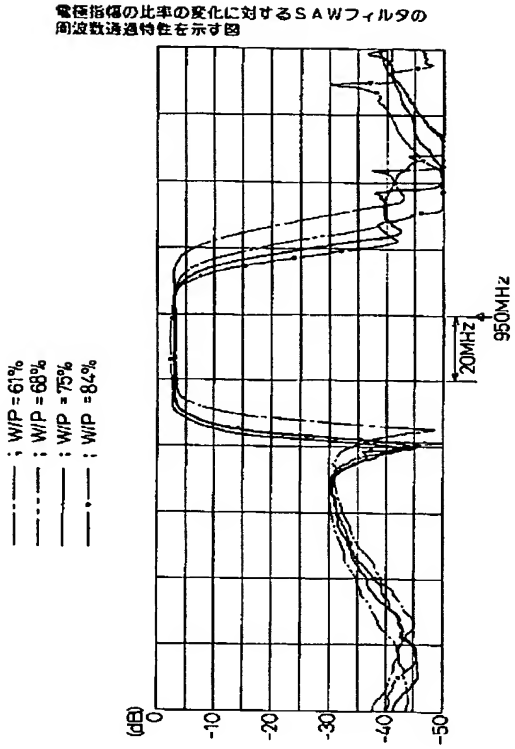
Ｐ…梯形電極の電極指のピッチ

Ｗ…電極指の幅

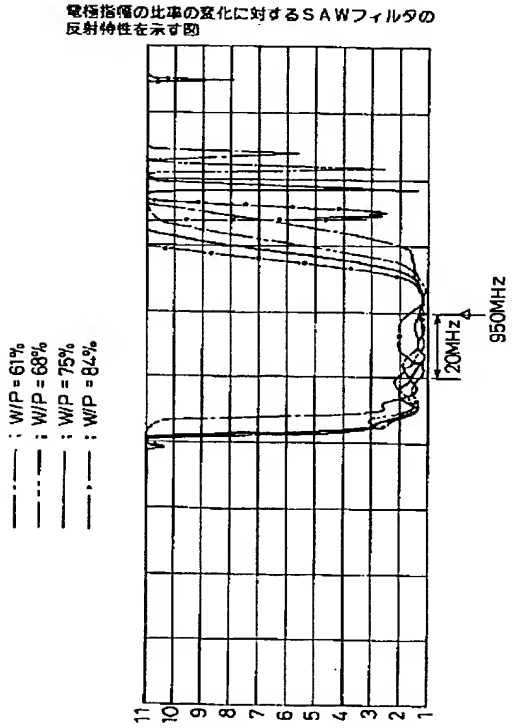
【図１】


本発明の一実施形態に係るＳＡＷフィルタの構成を示す図
L1
SF1
SF2
L2
IN
OUT
(a)
PF1
PF2
PF3
L3
L4
L5
GND
GND
P
W
(b)
W/P>50%
(W/P=60%~80%)

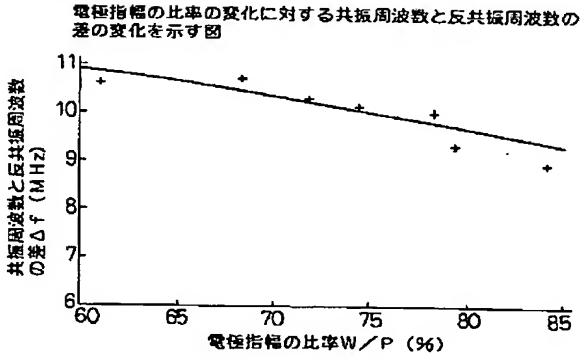
【図２】


電極指幅の比率の変化に対するＳＡＷフィルタの
周波数通過特性を示す図
; W/P=61%
; W/P=68%
; W/P=75%
; W/P=84%
950MHz
20MHz
(dB)
0
-10
-20
-30
-40
-50

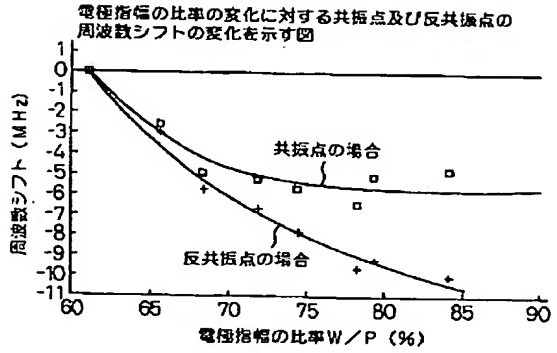
【図３】


電極指幅の比率の変化に対するＳＡＷフィルタの
反射特性を示す図
; W/P=61%
; W/P=68%
; W/P=75%
; W/P=84%
950MHz
20MHz
11
10
9
8
7
6
5
4
3
2
1

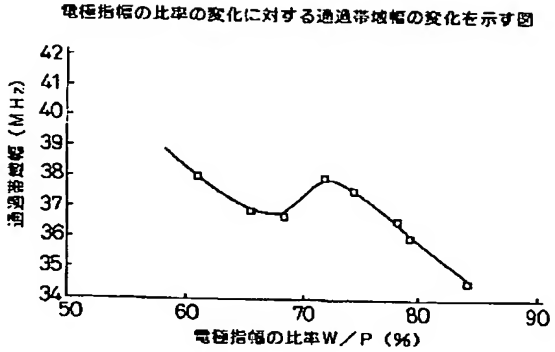
【図４】


電極指幅の比率の変化に対する共振周波数と反共振周波数の
差の変化を示す図
共振周波数と反共振周波数
の差Δｆ（ＭＨｚ）
11
10
9
8
7
6
60
65
70
75
80
85
電極指幅の比率Ｗ／Ｐ（％）

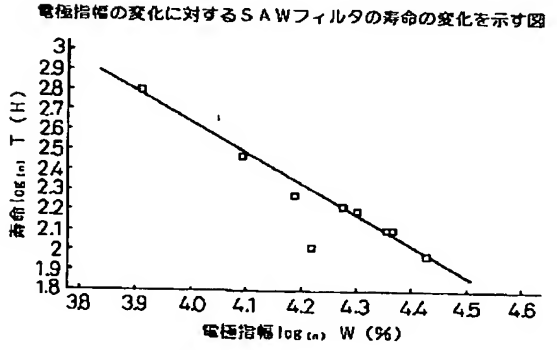
【図５】



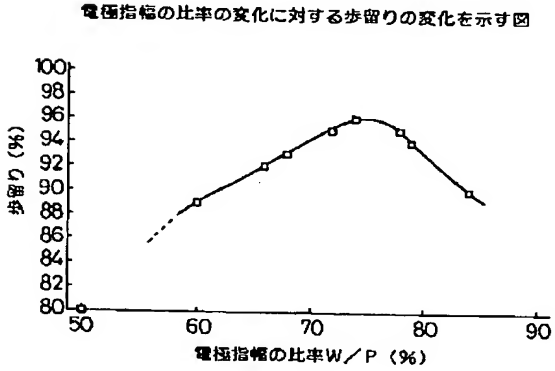
【図６】



【図７】

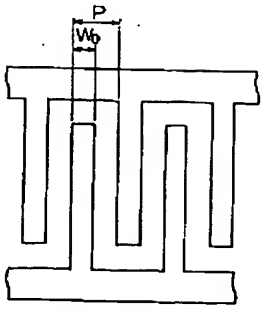


【図８】



【図１０】

従来形のＳＡＷ共振器を構成している櫛形電極の一部のパターン図



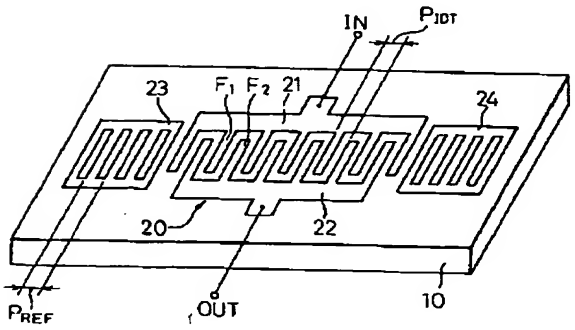
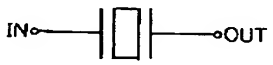
W0/P=50%

W0 = λ/4

【図９】

典型的なＳＡＷ共振器の一構成例を示す図

(a)



(b)